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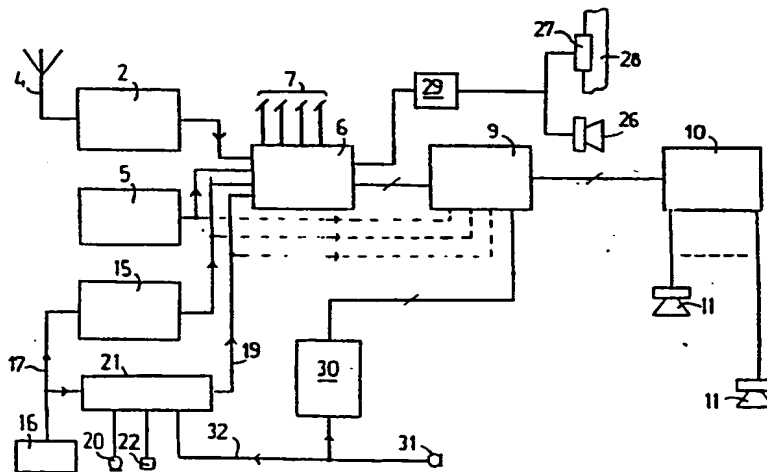
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**(54) Title:** SOUND SYNTHESIZER IN A VEHICLE



**(57) Abstract**

A noise enhancement system for use in a vehicle comprises a source (15, 20, 22) of signals representing desired sound related to vehicle operation for example the sound of a high power engine being accelerated. In dependence on sensed vehicle operation or experience, the signals are fed, to one or more loudspeakers (11, 26) or vibration actuators (27) so as to create for occupants of the vehicle a desired sound experience. The system can be integrated with one or both of an in-car entertainment system and a noise cancellation system.

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## Sound synthesizer in a vehicle

### DESCRIPTION

The invention relates to the treatment of noise in vehicles, in particular road vehicles.

5       The driver and passengers in the cabins of conventional passenger cars are exposed to a great deal of externally generated noise, due primarily to the vehicle engine. Various proposals have been made for reduction of such ambient noise but the present  
10 invention is concerned with the enhancement of the vehicle noise experienced by the cabin occupants during normal driving conditions.

According to the invention, there is provided a noise enhancement system for use in a vehicle, the  
15 system comprising a source of signals representing desired sound related to vehicle operation, and means selectively operable and/or responsive to vehicle operation or experience to apply the signals to one or more loudspeakers or other transducers or vibration  
20 actuators so as to create for occupants of the vehicle a desired sound experience.

The source of the signals representing desired sound can be a prerecorded source and/or one or more transducers responsive to noise or to operation of the  
25 vehicle or its engine. The transducer means can thus comprise for example one or more microphones or vibration sensors, preferably associated with signal treatment means. The transducer outputs can thus be simply shaped to provide the desired sound. Instead,

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the signals providing the desired sound can be obtained from a microprocessor-controlled synthesizer to which the transducer output is supplied, this output being employed to trigger the synthesizer to provide the  
5 desired signals at appropriate times. One or more microphones can be located in the vehicle cabin to provide feedback to the signal treatment means. The microprocessor controlling a synthesizer can store signals representing a desired sound to which the  
10 synthesizer can be arranged to adapt the transducer output.

The sounds heard by the user of a system embodying the invention can represent for example the sounds of a racing car or other high-performance road vehicle. The  
15 system can then be such that these sounds are heard by the cabin occupants whilst the vehicle is being driven, so as to enhance the occupants driving experience.

In particular, the sounds of a high powered engine undergoing sharp acceleration can be produced in  
20 response to acceleration of a vehicle fitted with the system of the invention in ordinary driving conditions. The system can be responsive for example to gear changes and/or throttle movement. The sounds need not be limited to engine noise; for example a warning  
25 sound, for example, the siren of a police car can be produced when a predetermined vehicle engine speed is exceeded.

The one or more loudspeakers and/or one or more vibration actuators of the system are typically located  
30 in the vehicle cabin but instead or as well one or more loudspeakers or actuators can be positioned in the engine compartment, or on appropriate engine or body parts to effect or to modify vibration thereof, so that the sound from them is heard by the vehicle cabin  
35 occupants, and by persons outside the vehicle by the

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same route as sound from the vehicle engine.

Although the system of the invention can stand alone, it is conveniently integrated with the in-car-entertainment (I.C.E) systems now typically provided in  
5 passenger cars. The vehicle operation related sound can be integrated with entertainment sound but is preferably produced in alternation with it, either selectively or according to vehicle operation; for example the former may be heard during acceleration  
10 only, giving way to entertainment sound once cruising speed has been reached. The system of the invention can also be integrated with an active noise reduction system which can reduce ambient noise by generating within the vehicle cabin sound vibrations of phase and  
15 amplitude such as to cancel or reduce unwanted noise. Noise reduction can thus be operative to prevent interference with the desired sound related to vehicle operation, as well as with entertainment sound, or it may be operative only as long as entertainment sound is  
20 being produced or when an integrated system is otherwise out of use.

The invention is further described below, by way of example, with reference to the accompanying drawing in which:

25 Figure 1 is a block circuit diagram of a combined audio entertainment and noise control or processing system embodying the invention; and

Figure 2 shows part only of a modified form of the system of Figure 1.

30 The system illustrated in Figure 1 is an integrated system comprising all the components necessary to provide in the cabin of a passenger motor car one or more of enhanced vehicle operation noise, audio entertainment, and ambient noise reduction, as  
35 the operator of the system may desire.

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The in-car entertainment (I.C.E.) components of the system comprise an audio signal source constituted by at least one of a radio tuner 2 connected to an aerial 4, and a deck or decks 5 for playing one or more  
5 of compact discs, digitally recorded tapes or cassettes. The outputs from the tuner 2 and deck or decks 5 are fed to a pre-amplifier 6 fitted with conventional control arrangements 7 for signal source selection and for output adjustment, such as volume and  
10 bass and treble controls, or graphic equalization, and switching instruments to be described. These I.C.E. components will typically provide signals on a plurality N of output channels and balance and fader controls will then be provided. The pre-amplifier  
15 outputs are supplied by way of a mixer 9, preferably a balanced mixer, to power amplifier means 10 which powers one or more loudspeakers 11 operative in the vehicle cabin.

For enhanced vehicle sound production, the system  
20 includes a prerecorded sound source 15 which can comprise a deck of one or other of the types of deck mentioned with reference to the deck 5, but which need not have the usual facility for selective replacement of the signal storage medium. Operation of the source  
25 15 is dependent on a control signal related to vehicle operation, typically throttle movement or gear changes, derived from a transducer 16 and supplied to the source on line 17, so that the source delivers signals representing the sounds of acceleration of a high  
30 powered vehicle, or other such desirable sounds, during acceleration or other operation of the vehicle in which the system is installed.

Instead of or as well as the source 15, the system includes one or more microphones 20 providing outputs  
35 representing actual vehicle engine noise or the



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operating noise of some other vehicle component, which is fed to the pre-amplifier 6, after treatment in a signal treatment unit 21. The signal treatment unit can comprise a relatively simple shaping circuit 21 where this can provide a satisfactory output to the pre-amplifier 6. Instead of or as well as the microphone or microphones 20, the system includes one or more transducers 22, for example vibration sensors, responsive to engine operation to provide signals to the preamplifier 6 after treatment in the signal treatment unit.

Instead of the shaping circuit 21, as shown in Figure 2, the signal treatment unit can be constituted as a synthesizer 24 controlled by a micro-processor 25. The input from the or each microphone 20 or transducer 22 is then used to trigger the generation of a desired output from the synthesizer. Enhanced engine or vehicle interior noise is again provided, again preferably at times dependent on vehicle operation, as by control from the transducer 16.

The outputs of the source 15 and the signal treatment unit are supplied to the pre-amplifier 6 on line 19 for sound production in the vehicle cabin by way of the amplifier means 10 and the loudspeakers 11. In addition or instead the pre-amplifier output derived from the source 15 or the signal treatment unit can be used to drive one or more loudspeakers 26 located externally of the vehicle cabin, for example, in or near the engine compartment of the vehicle so as to enhance the sound actually produced by the vehicle engine, and/or a vibration actuator 27 operatively related to a vehicle panel 28. The loudspeaker 26 and/or actuator 27 is powered by way of one or more power amplifiers 29.

For noise reduction, the system includes an

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adaptive noise cancellation controller 30 which may advantageously be of the kind described in WO 88/02912, the contents of which are incorporated herein by reference. The controller 30 provides, on L channels, 5 output signals derived from a reference signal by adaptive filtering carried out by a programmed microprocessor and memory unit in dependence on error signals from one or more microphones 31. The microphones 31 may be inconspicuously located in the 10 cabin and the reference signal may be derived directly from the vehicle engine, as described in WO 88/02912.

The output of the one or more microphones 31, or of one or more similarly located microphones if no noise reduction facilities are provided, can be fed 15 back to the signal treatment unit 21 or to the microprocessor 25, on line 32, so as to provide adaptive control of the unit, as towards a predetermined enhanced noise signal defined in a memory in the unit or in the microprocessor.

20 The outputs from the pre-amplifier 6 and the controller 30 are fed to the balanced mixer 9 operative to provide outputs for the power amplifier means 10 combining a desired audio signal from one or other of the sources 2 and 5 together with a noise cancelling 25 signals from the controller 30, on which the amplifier control arrangements 7 have no effect.

The system is provided with an on/off switch controlling the power amplifiers 10 and 19 and the mixer 9, and selector switches for selecting any one or 30 more of the enhanced noise facility, the entertainment facility, and the noise reduction facility.

The loudspeakers 11 will conveniently match in number the number of the output channels of the pre-amplifier 6, but there may be M channels between the 35 balanced mixer 12 and the amplifiers 15, where M is

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equal to or greater than the larger of the N entertainment channels or the L noise reduction channels.

One or more of the sources 5 and 15 and the unit 5 21 may incorporate a pre-amplifier and the output or outputs can then be supplied to the mixer 9 directly as indicated in the figure by broken lines.

It will be evident that the invention can be embodied in a variety of ways other than as herein 10 described.

## CLAIMS

1. A sound enhancement system for a vehicle, the system comprising a source of signals representing desired sound and means (6,16) selective responsive to vehicle operation and/or means (11,17) so as to create for an vehicle a desired sound experience.
2. A system as claimed in claim 1, wherein the source of signals representing the desired sound comprises at least one of a prerecorded signal (15), at least one microphone (20) for picking up vehicle or engine noise, and a vibrator (15) responsive to vehicle or engine-generated sound.
3. A system as claimed in claim 1, wherein the source of signals representing the desired sound comprises one or both of the microphone (22) and wherein a signal processor (22) is arranged to shape the signals therefrom to provide the outputs.
4. A system as claimed in claim 1, wherein the source of the signals representing the desired sound comprises one or both of the microphone (22) and wherein a signal processor (22) is arranged to shape the signals therefrom to provide the outputs.
5. A system as claimed in claim 1, wherein the source of signals representing the desired sound comprises a microprocessor (25) controlling the signals and includes a store in which are stored signals representing a desired sound, and the microprocessor (25) is arranged to adapt the signals from the stored signals.
6. A system as claimed in claim 1, wherein the source of signals representing the desired sound is in association with a noise cancellation system.

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including an error sensing microphone (31), the microphone output being supplied to the signal treatment unit (21;24,25) for adaptive control thereof.

7. A system as claimed in any preceding claim  
5 wherein the signals are employed to provide the outputs in response to signals from a transducer (16) responsive to vehicle operation.

8. A system as claimed in any preceding claim  
10 wherein the transducer means comprises one or more loudspeakers (27) located in the region of the vehicle engine.

9. A system as claimed in any preceding claim wherein the transducer means comprises one or more loudspeakers (11) located in the vehicle cabin.

15 10. A system as claimed in claim 8 wherein the loudspeakers (11) form part of at least one of an in-car entertainment system and a noise cancellation system.

20 11. A system as claimed in any preceding claim wherein the transducer means comprises at least one actuator for causing vibration of a vehicle panel.

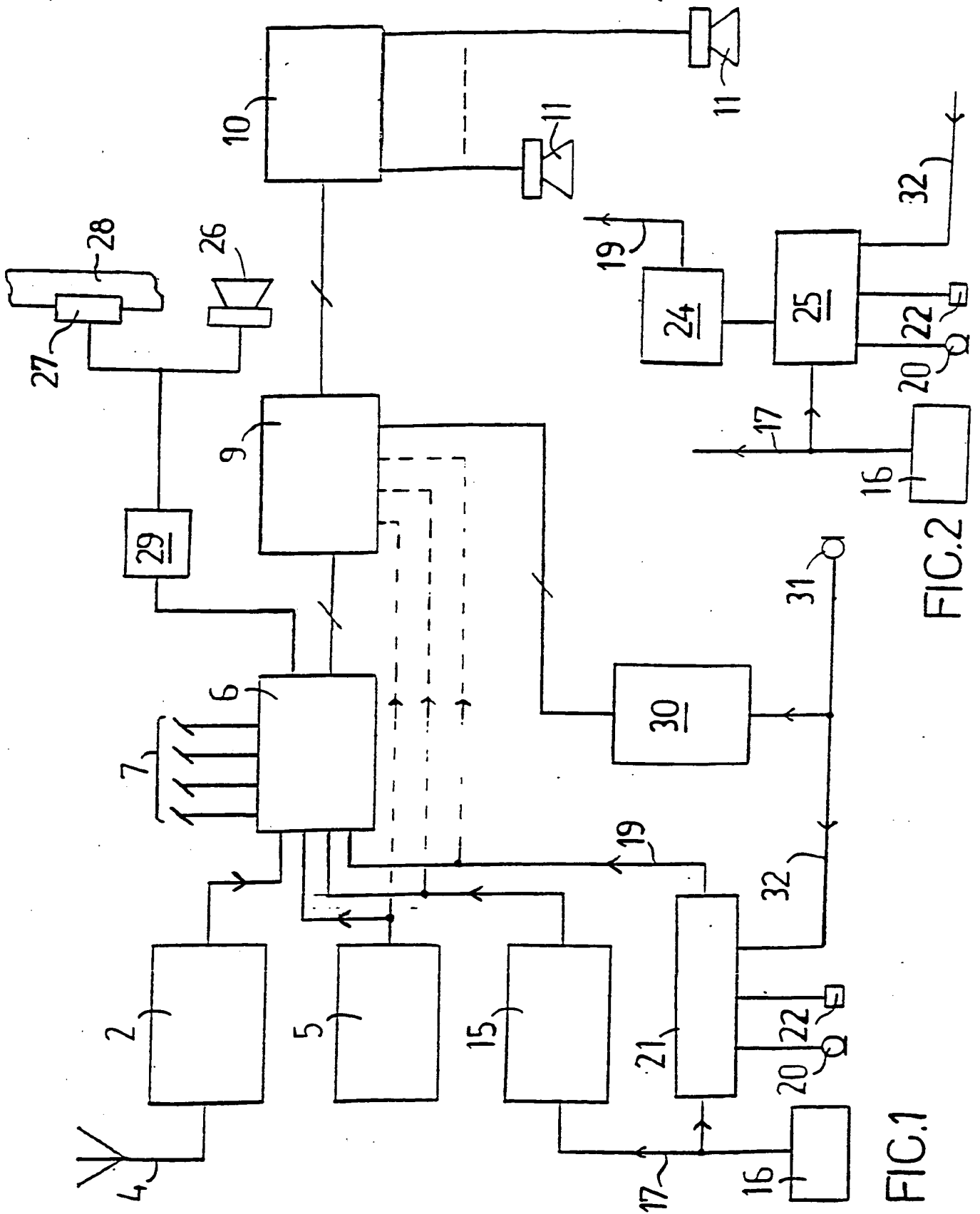
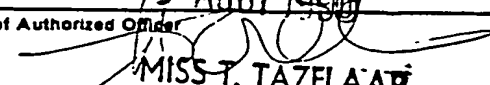


FIG.1

FIG.2

# INTERNATIONAL SEARCH REPORT

International Application No. **PCT/GB 90/00597**

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC <b>IPC<sup>5</sup>: G 10 K 15/02</b>		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
<b>IPC<sup>5</sup></b>	<b>G 10 K, A 63 H, G 09 B</b>	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
A	US, A, 4274225 (KNAUFF et al.) 23 June 1981 see column 3, lines 37-48; figure 1 --	1
A	US, A, 4289307 (MARSHALL et al.) 15 September 1981 see column 2, line 58 - column 3, line 9; column 4, lines 19-32; figure 1 --	2
A	US, A, 4219962 (DANKMAN et al.) 2 September 1980 see column 2, lines 35-38; column 6, lines 37-44; column 7, lines 21-53; column 9, lines 31-36 --	1
A	DE, A, 2734948 (INDUSTRIEANLAGEN -BETRIEBS-GESELLSCHAFT) 15 February 1979 ./.	5
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Z" document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search <b>16th July 1990</b>		Date of Mailing of this International Search Report <b>15 AUG 1990</b>
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, ** with indication, where appropriate, of the relevant passages	Relevant to Claim No.
	see page 2, lines 2-11 --	
A	WO, A, 88/02912 (ADAPTIVE CONTROL LTD) 21 April 1988 see abstract; figure 5 (cited in the application) --	6
A	GB, A, 2018144 (MABUCHI MOTOR K.K.) 17 October 1979 see page 1, lines 37-56  -----	11



**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4274225	23-06-81	None	
US-A- 4289307	15-09-81	CA-A- 1123024	04-05-82
US-A- 4219962	02-09-80	None	
DE-A- 2734948	15-02-79	None	
WO-A- 8802912	21-04-88	GB-A- 2203016	05-10-88
		EP-A- 0285632	12-10-88
		GB-A- 2201858	07-09-88
		JP-T- 1501344	11-05-89
GB-A- 2018144	17-10-79	JP-A, B, C 54123342	25-09-79
		DE-A, C 2909523	20-09-79
		US-A- 4258499	31-03-81

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